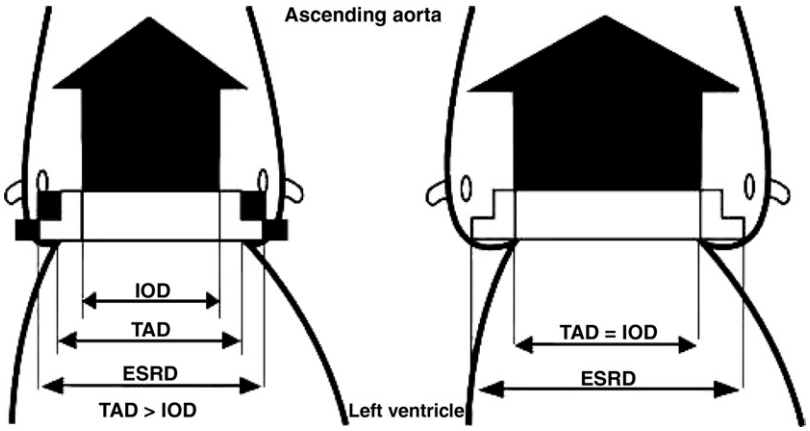

Figure 1. The schematic drawing shows two aortic root anatomies with an identical tissue annulus diameter *(TAD).* The *right figure* shows a more bulbar-shaped root. This is the ideal situation for complete supra-annular placement, in which the TAD corresponds to the internal orifice diameter *(IOD)* of the prosthesis (TAD = IOD). The *left figure* shows a narrow aortic root. Despite the same TAD, a completely supra-annular valve of the same size *(gray)* would not fit in. Thus a smaller valve *(white)* has to be chosen with the consequence that, despite implanting a completely supra-annular prosthesis, stent and sewing ring material impair the bloodstream. Thus the shape of the aortic root does not allow the implantation of a valve large enough to ensure that the IOD corresponds to the TAD. This illustrates the hypothesis that hemodynamic benefit cannot be achieved in every aortic root because of a completely supra-annular placement of the prosthesis. *ESRD,* External sewing ring diameter.

Walter Eichinger reports lecture fees from Edwards Lifesciences and St Jude Medical. Ruediger Lange reports lecture fees from Edwards Lifesciences and the Sorin Group.

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Reply to the Editor:

We appreciate the comments of Eichinger, Hettich, and Lange on our recent article reporting on in vitro performances of 5 different aortic tissue valves designed for supra-annular implantation.[1]

We agree that the complex aortic root anatomy is responsible for different findings and different prosthesis fittings, because larger sewing rings and higher profiles may play a crucial role in terms of encumbrance in the sinus portion of the aorta. We selected the largest prostheses of each model that could be fitted in a 21-mm valve holder regardless of the manufacturer's size. We observed that the valves with the more advantageous ratio between internal orifice versus tissue annulus–sewing ring diameters were the Sorin Mitroflow (Sorin Biomedica Spa, Saluggia, Italy) and the Carpentier-Edwards Magna bioprostheses (Edwards Lifesciences, Irvine, Calif). Unfortunately, the Mitroflow valve has not been studied by Eichinger, Hettich, and Lange. Nevertheless, comparing the hydrodynamic performances of the Sorin Soprano versus the Carpentier-Edwards Magna, we did not observe significant differences between the two valves, such as those observed by this group in vivo.[2] Eichinger's group highlights the beneficial ratio between internal and sewing ring diameters as well as the hemodynamic performances of the Carpentier-Edwards Magna valve. In vivo, the beneficial effect was observed only when comparing patients with a larger tissue annulus diameter (between 21 and 23 mm); surprisingly, this benefit disappeared for the smaller diameters (18-20 mm). We believe that the beneficial ratio between internal orifice diameter and sewing ring diameter is valid also for 19- or 21-mm prostheses and not only for the larger prosthesis sizes. Moreover, since the upsizing of the Medtronic Mosaic (Medtronic, Inc, Minneapolis, Minn) versus the Carpentier-Edwards Magna prosthesis was not possible in our in vitro study, we maintain that the hemodynamic benefit, observed in vivo with the Carpentier-Edwards prosthesis in comparison with the Medtronic Mosaic by Eichinger and coauthors,[3] results mostly from the different internal orifice diameters and tissue annulus diameters rather than from the prosthesis up-

sizing,[4] as observed in our in vitro comparison.[1] Moreover, considering the excessively and surprisingly high regurgitant volumes observed in vitro with the Carpentier-Edwards Magna valve, as well as the minimal tolerability of this valve to stent distortion, according to present work and to other experiences in the literature,[5,6] the upsizing of the Carpentier-Edwards Magna should be, to our mind, carefully considered.

Unfortunately, "in vivo" comparisons between different prostheses are difficult and misleading; several confounding factors, such as blood viscosity (patient hematocrit), heart rate, left ventricle and mitral valve pattern, cardiac output, septum hypertrophy, systemic hypertension, reduced systemic arterial compliance, and effects of angiotensin-converting enzyme inhibitors in hypertensive patients, data that are rarely reported in clinical studies, are frequently present. These factors may confound the data obtained by echocardiographic studies. Other important factors such as aortic root anatomy or variability in surgical skill and implant technique might indeed affect clinical comparisons. Finally, echocardiography parameters (ie, effective orifice area calculated by using the continuity equation) have inherent variability that is mainly related to the techniques used for its measurement, as well as to flow dependency. For these reasons, we maintain that it is hazardous to conclude that a prosthesis model is the gold standard by interpreting only clinical results.

The system that we have used has a virtually rigid arrangement section downstream from the aortic valve, which represents perhaps the single largest distortion from reality. Attachment of a small compliant device to the downstream section could give a significantly different system performance, mimicking an in vivo setting such as an aorta setting. However, if we compare two heart valves in this modified system, we would expect to appreciate the same differences between the two different valves. Therefore, the pulse duplicator device is not really designed to give an accurate representation of the true anatomy; rather, it is a system that provides an extraordinary and unquestionable bench test for comparison of different prostheses.

The most striking finding of our study was the ability to obtain a unique hydrodynamic comparison of different models of supra-annular tissue valves fitting a 21-mm diameter artificial aortic annulus, regardless of the labeled manufacturers' size. This comparison can be helpful in assisting surgeons' decisions.

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Nitric oxide precursors and congenital cardiac surgery: A randomized controlled trial of oral citrulline. Definition of pulmonary hypertension in Fontan circulation?

To the Editor:

We read with great interest the article from Smith and colleagues[1] describing the effect of citrulline supplementation in reducing postoperative pulmonary hypertension. This is very appealing therapy because it is reported to be effective and without any side effects.

Nevertheless, we have a concern with the definition of pulmonary hypertension. The authors have used the accepted definition of pulmonary hypertension as a mean pulmonary arterial pressure of at least 25 mm Hg[2] or exceeding 50% of the mean systemic artery pressure. Although acceptable for patients presenting with ventricular or atrioventricular septal defect, as well as transposition of the great arteries, this definition is more questionable for bidirectional Glenn and Fontan procedures.

A prerequisite for a successful bidirectional Glenn or Fontan procedure would be a mean pressure of less than 15 mm Hg. In addition, a pressure of more than 12 mm Hg in a Fontan circulation would be considered a suboptimal result.

Taking 25 mm Hg as a limit to describe high pulmonary pressure in this group induces a significant bias to our point of view. Assuming that we use 15 mm Hg as the limit for the Glenn and Fontan group, all patients (11/11) presented with pressure of more than 15 mm Hg in the placebo group, and 9 of 10 patients presented with this pressure in the citrulline group. Taking 20 mm Hg as a superior limit, 4 of 11 in the placebo group presented with pressure over the limit compared with 4 of 10 in the citrulline group, respectively.

On this basis, we think that groups with shunt lesions and biventricular repair versus single-ventricle physiology should not be evaluated similarly with regard to pulmonary hypertension.

Another concern, and this is applicable to both shunt lesions or single-ventricle circulation, is that nothing is reported with regard to postoperative care, and several confounding factors can increase or decrease pulmonary arterial pressures in this period, such as pH, Po_2, sedation, ventricular function, pulmonary wedge or atrial pressures, and inotropic/vasodilatory support for 48 hours.[3]

We think these points are of major importance because citrulline levels might not have been the sole responsible variable for reducing pulmonary arterial pressure.

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